

# Potential Future Directions for the Division of Applied Science and Technology



John W. Haller, Ph.D.

Acting Director

Division of Applied Science and  
Technology

NACBIB, May 25-26, 2005

# Division of Applied Science and Technology

**Magnetic Resonance Imaging**

**Magnetic/Biomagnetic/Bioelectric Devices**

**Surgical Technologies**

**Image-Guided Therapies and Interventions**

**Nuclear Medicine**

**Image Processing, Displays, and Perception**

**Molecular Probes and Imaging Agents**

**Optical Imaging and Spectroscopy**

**Ultrasound, Photoacoustics and Thermoacoustics**

**X-ray, Electron and Ion Beam (including CT)**

# Potential Future Directions

- Optical Imaging
- Imaging Agents
- Imaging Informatics
- Image-Guided Interventions
- *In vivo* micro-imaging

# Scope of the Imaging Agent Program

---

## Imaging Agent Portfolio

- contrast agent development and
- molecular imaging agents



# Scope of the Optical Imaging Program

---

## Optical Imaging Portfolio

- Optical coherence tomography
- Fluorescence imaging;
- Multiphoton microscopy;
- Infrared and near-infrared microscopy;
- Microwave imaging;
- Terahertz
- Scanning probe microscopy;
- Fiber optics.



# Optical Imaging and Image Agent Portfolio

Optical Imaging Technologies	\$16M	59 Grants
Imaging Agents*	\$12.8 M	36 Grants

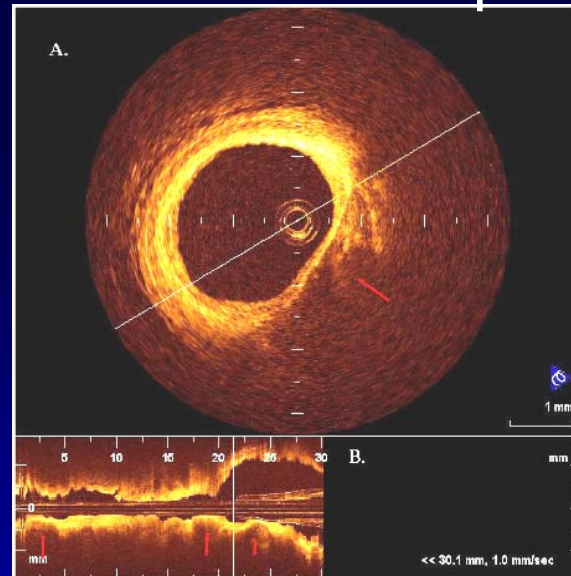
\*Predominantly optical imaging agents

**Approximate Dollars in Millions, # of Grants**

# POTENTIAL FUTURE DIRECTION for OPTICAL IMAGING

## *In vivo OCT imaging*

- **Background:** Optical Coherence Tomography (OCT) is prime for translation from the lab to *in vivo* imaging
- **Direction:** Develop *in vivo* OCT imaging technologies (e.g., intravascular OCT of vulnerable plaques)



*In Vivo Human Imaging (A) plaque indicated by the red arrow, and (B) viewed along the catheter length.*

# POTENTIAL FUTURE DIRECTIONS

## *Activatable Imaging Agents*

- **Background:** Activatable agents allow imaging of specific cellular processes, such as enzyme activities, gene expressions, etc.
- **Direction:** Develop new “smart,” activatable imaging agents that are activated in response to changes in the local biochemical environment.



# Scope of the X-Ray, Nuclear Medicine, Ultrasound Programs

- **X-Ray and X-ray CT**

- Flat-panel imager/digital radiography development; Digital tomosynthesis, Flat-panel CT; CT reconstruction algorithms; CT dose reduction; Dosimetry.

- **Nuclear Medicine**

- New crystal scintillators, novel image-receptor designs; New collimator designs; Improved and multi-modality animal systems; Radiopharmaceuticals for molecular imaging; Dual-isotope imaging; Dosimetry.

- **Ultrasound**

- Very high frequency (50 – 200 MHz) US; Piezoelectric/capacitive element and transducer development; Novel imaging/Doppler systems; US contrast agents/harmonic imaging; Elastography, tissue property quantification; Focused ultrasound for therapy;

# X-ray, CT, Nuclear Medicine, PET, Ultrasound Portfolio

Nuclear Medicine (inc. PET)	\$22.2M	68 Grants
Ultrasound	\$12.0M	36 Grants
X-Ray and CT	\$12.3M	38 Grants

Dollars in Millions

# POTENTIAL FUTURE DIRECTIONS

## *Imaging informatics*

- **Background:** Imaging systems (e.g., CT, MRI) have developed to a point where there is a data overload.
- **Direction:** Support of imaging informatics, computer-aided detection and diagnosis, and visualization tools for biomedical imaging.

# Scope of the Image-Guided Interventions (IGI) Program

- IGI Devices/Tools
  - e.g., robotics, probe tracking, imaging hardware and software
- IGI Applications
  - Image-Guided Surgery
  - Cancer Treatment or Biopsy
  - Cardiovascular Interventions
  - Neuro-Interventions

# Image-Guided Interventions (IGI) Portfolio

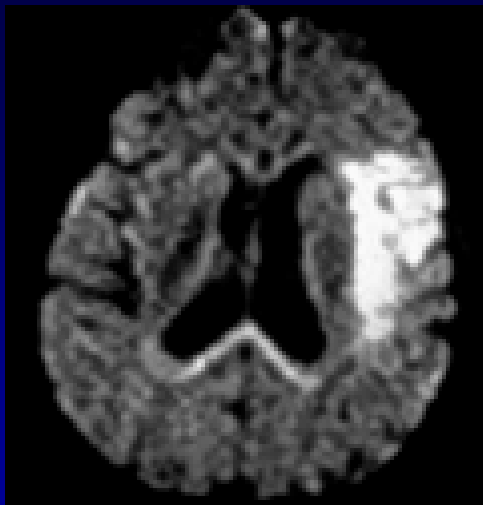
<b>IGI</b>	<b>\$12M</b>	<b>38* grants</b>
------------	--------------	-------------------

\* 11 R21 Grants expire  
Aug. 31

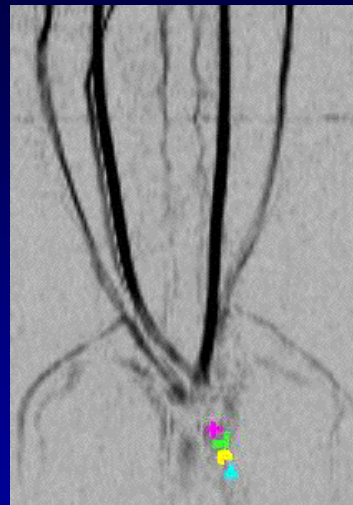
# POTENTIAL FUTURE DIRECTIONS

## *Combine image-based diagnosis with image-guided treatment*

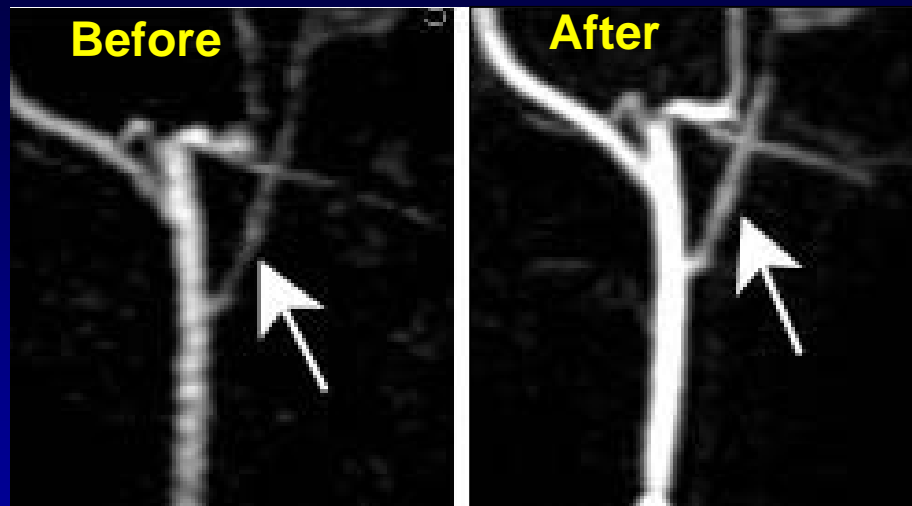
- **Background:** In some common life-threatening conditions time-to-treatment is a critical factor (e.g., stroke, infarct, trauma).
- **Direction:** Combine detection, diagnosis and treatment in a single patient visit.



1) Diagnostic MRI.



2) Image-guided catheter tip

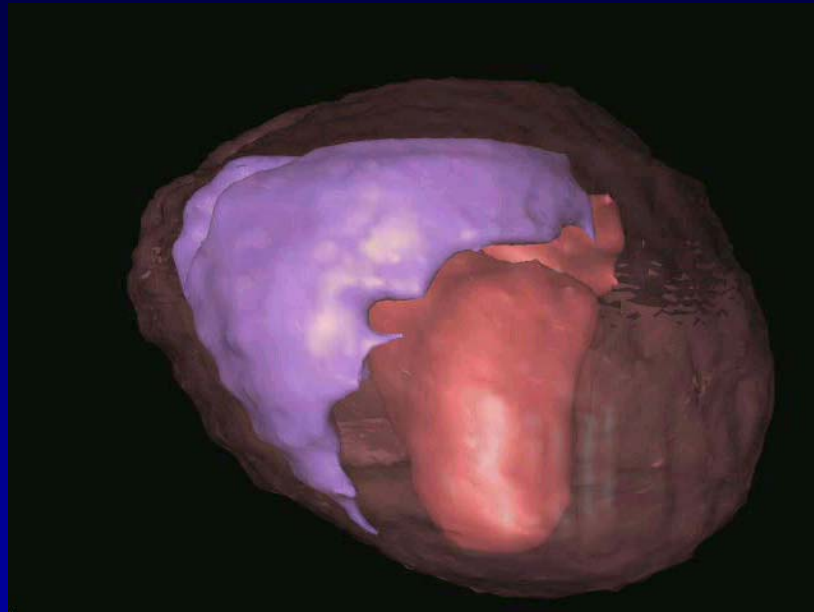


3a-b) MRA assessment of treatment effect.

# POTENTIAL FUTURE DIRECTIONS

## *Real-time Imaging for IGI*

- **Background:** IGI imaging modes need to operate in real time in the OR. Need fast acquisition/ segmentation, multi-modality image fusion, modeling of tissue deformation, etc.
- **Directions:** Develop technologies for 4D (real-time 3D) imaging for image-guided interventions



# Scope of the MRI, EPR Portfolio

- MRI Physiological imaging
  - MR spectroscopy
  - RF coil design
  - fMRI
- 
- Solid-state Nuclear Magnetic Resonance (NMR)
  - Electron Paramagnetic Resonance (EPR)



# MRI, EPR Portfolio

MRI Techniques	\$17.7 M	55 grants
MRI Instruments	\$11.0 M	24 grants
fMRI	\$5.2 M	17 grants
<i>in vivo</i> EPR	\$5.3 M	9 grants
Solid State NMR	\$8.0 M	18 grants
Other (synchrotron, <i>in vitro</i> EPR mass spect, etc.)	\$6.5	12 grants

# POTENTIAL FUTURE DIRECTIONS

## *Clinical Microimaging of Internal Organs*

- **Background:** Early detection and characterization of disease is difficult because of poor sensitivity and spatial resolution of imaging tools for internal organs (e.g., pancreatic islet cell imaging, liver cancer)
- **Direction:** Microimaging with small “microdevices” that are inserted into the body. Multimodal, image-guided devices with high sensitivity and spatial resolution.
- (e.g. very high frequency (50–200 MHz), very high-resolution ultrasound, OCT, MRI microcoils)

# DAST Potential Future Directions

1. *In vivo OCT imaging*
2. *Activatable Imaging Agents*
3. *Imaging Informatics*
4. *Combining diagnostic imaging with image-guided treatment*
5. *Real-time Imaging for Image-Guided Interventions*
6. *Clinical Microimaging of Internal Organs*